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(54) Electronic tilt-sensitive device

(57) The device comprises a vial 1 containing a chamber 2 which is filled with an electrically conductive liquid 3 save for a tilt-sensitive bubble 4 which moves in contact with the upper surface 5 of the chamber. Two sensing electrodes S1, S2 are inserted in the top wall 7 of the chamber either side of and in close proximity to the ends of the bubble 4. These end flush with the internal surface 5 of the chamber, and a reference electrode A1 is also inserted through the wall of the vial to remain in contact with the liquid as the vial is tilted. When the device is in a level or other datum position a circuit exists between the reference electrode and both sensor electrodes, and an electronic circuit detects this and operates a green LED and a sounder. If however the device is tilted, one of the sensor electrodes is covered by the bubble to break the corresponding circuit, which causes a corresponding red LED to light up to indicate in which direction the device must be moved to restore it to the datum position.

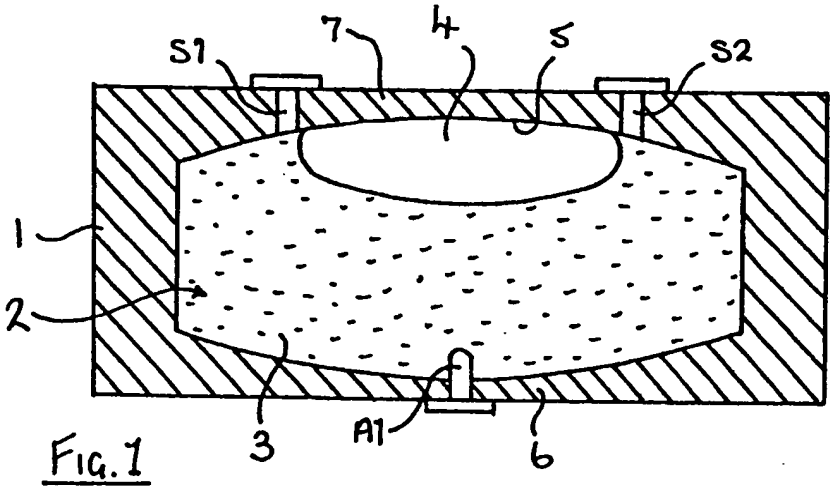

Fig. 1

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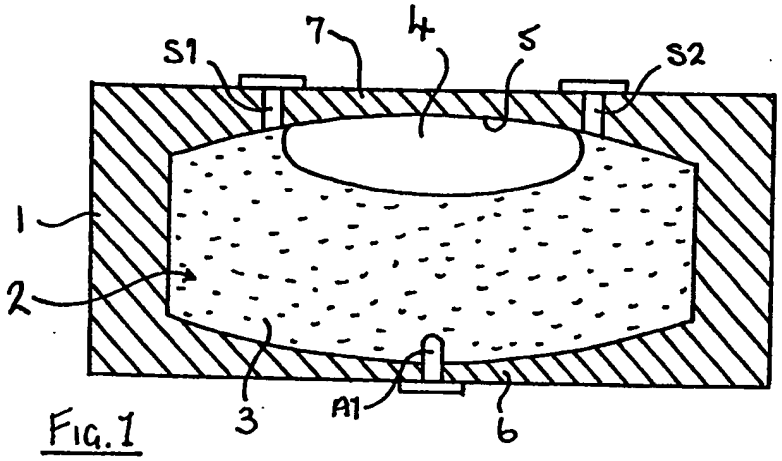

Fig. 1

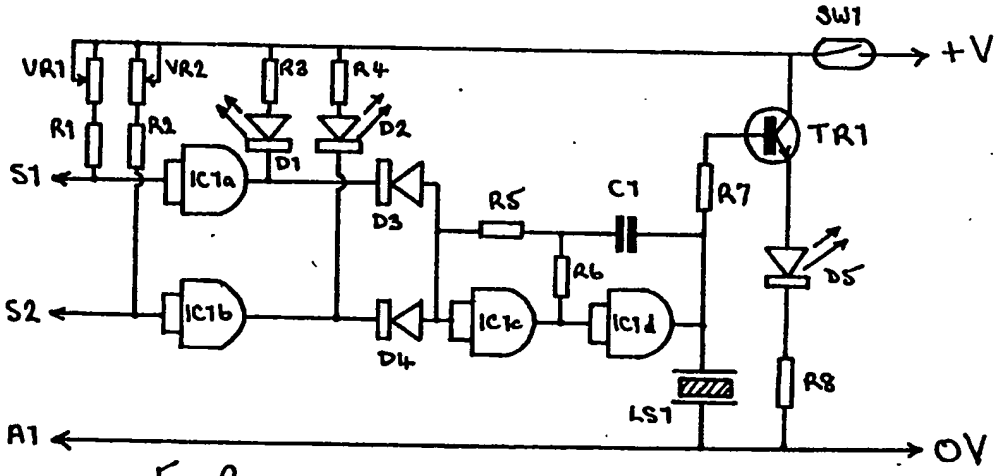

Fig. 2

SPECIFICATION

Electronic tilt-sensitive device

Conventional spirit levels have several disadvantages, the main one of which is that the position of the bubble can only be seen accurately from very close proximity. An illustration of this is seen when the level is used on a long length of timber. This either requires two people, one to watch the bubble and the other to move the timber up and down at one end, or one person working alone must keep going back and forth alternately making adjustments and checking the position of the bubble. A similar situation arises when a builder has to level a girder or other support above head level, or when levelling a caravan or mobile home. The task becomes even more difficult under poor light conditions.

Various solutions to this problem have been proposed, some of which are to be found in United Kingdom patent Specification No. 993 715. This proposes the use of a sealed tube containing an electrically conductive liquid and a bubble, a reference electrode in continuous contact with the liquid, and two end electrodes spaced well away from the ends of the bubble so that they do not normally come into contact with it. The position of the bubble is detected by comparing the minute differences in electrical resistance between the reference electrode and each of the end electrodes as the bubble moves within the liquid. Whilst such an arrangement might be capable of accurate measurement it is believed that it would be very sensitive to set up, and therefore most unlikely to maintain any degree of accuracy over a prolonged period.

That patent specification also refers to known devices in which a bubble moves in contact with a flat surface at either end of which there is an end electrode, and which yields an on-off signal. It is not known to what this refers but it is clear that such a device could not, as described, provide an accurate indication of tilt.

The aim of the present invention is to provide a device which could be used from some distance away to accurately adjust a surface to a datum position (e.g. horizontal or vertical), which is inexpensive to produce, and which is capable of accurate and reliable results.

The solution offered by the present invention lies in an electronic tilt-sensitive device comprising:

- a sealed chamber containing an electrically conductiv liquid and a relatively non-conductive fluid, the chamber having reference electrod means which normally r mains in l ctrical c ntact with the liquid as the chamber is tilted either side of a datum position, and at least two sensing electrodes arranged such that when th chamber is in the datum position they are in contact with the liquid but when the chamber is tilted either side of th datum position a respective sensing electrode comes into contact with the non-conductive fluid thereby breaking the circuit between that electrode and the reference electrode,
- an electronic circuit for sensing the presence or absence of an electrical circuit between the reference electrode and each of the sensing electrodes, and
- indicator means operable by the said electronic circuit to indicate (i) when the chamber is in the datum position, (ii) when the chamber is tilted to one side of the datum position, and (iii) when the chamber is tilted to the opposite side of the datum position.

The device therefore not only tells the user when the datum position has been attained but also indicates in which direction the device must be tilted to attain that position.

In order to provide an accurate and reliable on/off signal it is highly desirable that the sensing electrodes terminate substantially flush with the internal surface of the chamber.

Although the non-conductive fluid may be a liquid which may even be of greater density than the conductive liquid so that it moves over the floor of the chamber, it is preferably a gas, and is most conveniently air.

Although acceptable results could be achieved with, say, a thin layer of liquid which, in the datum position, covers the floor of the chamber but which uncovers one of the sensing electrodes which are mounted in the bottom of the chamber when the chamber is tipped, better stabilisation will be achieved if the chamber is substantially filled with the liquid and the non-conductive fluid is in the form of a bubble which moves in contact with an internal surface of the chamber. Thus, the sensing electrodes will normally be arranged such that, when the chamber is in the datum position, they are on opposite sides of and in close proximity to the bubble so that they will be uncovered with even a slight inclination of the chamber relative to the datum position.

Although many electrically conductive liquids may be suitable, it has been found that fluids with a high but measurable electrical resistance give most reliable results, particularly in combination with CMOS input circuitry. (The resistance of wood alcohol as used in conventional spirit level vials is unmeasurable.) Furthermore, the liquid is preferably of relatively low density compared with water so that rapid stabilisation is achieved. The ideal liquid is also of comparatively low surfac tension to reduce meniscus errors.

Many different forms of lectronic circuit may b devised for us in the devic .

The indicator m ans may provide a visual and/or audible indicati n of the three states, although LED indicators are particularly preferred as they are visible under poor light conditi ns.

The invention includes a vial for use in the device comprising a chamber of the form described above.

The invention will now be exemplified in the following description to be read in conjunction with the accompanying drawings, in which:

Figure 1 is a diagrammatic sectional view of the sensing vial of a tilt-sensitive device in accordance with the invention, and

Figure 2 is the electrical circuit diagram of the device.

The device comprises a vial 1 (see fig. 1) of plastics, glass or any other suitable material containing a horizontal barrel-shaped chamber 2. The chamber is filled with methylated spirit 3 save for an air bubble 4 which naturally rises into contact with the smooth concave upper surface 5 of the chamber. A brass pin A1 is inserted through the lower wall 6 of the vial and protrudes into the chamber 2 to form a reference electrode in contact with the spirit 3. Two similar pins S1, S2 are inserted through the upper wall 7 of the vial to form a pair of sensing electrodes, but these end flush with the internal upper surface 5 of the chamber. They are however still in direct electrical contact with the spirit 3. The pins S1 and S2 are symmetrically disposed about the centre of the chamber 2 and their spacing is slightly greater than the length of the bubble 4.

For the purpose of illustration, the present device is intended for use in checking and adjusting surfaces for level, although it may be designed for checking any desired angle of inclination from horizontal to vertical. In the present device however, the vial is mounted in a conventional elongate box section housing with the axis of the vial substantially parallel to the axis of the housing. The inclination of the vial is then accurately adjusted so that when the housing is placed on a level surface the bubble is positioned precisely between the sensing electrodes S1 and S2. There will thus be an electrical circuit from the reference electrode to each of the sensing electrodes through the spirit 3. If on the other hand the device is tilted slightly the bubble will move so as to cover one of the electrodes S1, S2 and the corresponding circuit will be broken. A circuit for detecting such a state will now be described.

Referring to Fig. 2, the circuit includes four CMOS inverters IC1a IC1d and an NPN switching transistor TR1. The inputs of IC1a and IC1b are each connected to a respective sensing electrode S1, S2 and the reference electrod A1 is connect d to the negativ supply rail. The inputs of IC1a and IC1b ar additionally connect d to th positive rail via r sistor c mbinations R1, VR1 and R2, VR2 respectively. VR1 and VR2 are adjusted so that when the device is level and a circuit theref r exists between th respective sensing electrode and the reference electrode, the input of the respective inverter will be low and its output will therefor be high. The outputs of IC1a and IC1b are connected to the positive rail via red LEDs D1 and D2 and respective series resistors R3, R4 so that when the outputs are high the LEDs are not illuminated.

IC1c and IC1d are connected as a simple oscillator in combination with resistors R5 and R6 and capacitor C1, which are chosen to give an oscillation frequency of about 3.5 KHz. The input of the oscillator is connected to the outputs of IC1a and IC1b via diodes D3 and D4. With the device level, as described in the preceding paragraph, D1 and D2 are both reverse biassed so that the high outputs of IC1a and IC1b do not reach the input of the oscillator enabling it to run. The output of the oscillator is connected to a piezo sounder LS1 and, via current-limiting resistor R7, to the input of the switching transistor TR1. The collector of TR1 is connected to supply positive whereas the emitter is connected to the negative rail via a green LED D5 and series resistor R8. Thus, when the oscillator is running, LS1 sounds and D5 is illuminated, both of which indicate that the device has attained a level condition. (Although D5 is driven at a frequency of 3.5KHz this appears constant to the naked eye.)

Suppose the device is now tilted slightly so that one of the sensor electrodes, say S1, is covered by the bubble. A circuit still exists between the reference electrode and electrode S2 so that LED D2 would remain off. On the other hand, no circuit would exist between elctrodes A1 and S1 so that the input of IC1a will go high via R1, VR1 and its output will go low causing LED D1 to light up. The low output of IC1a also reaches the input of the oscillator via D3 so that the oscillator is disabled. Both the sounder and the green LED D5 therefore cease to operate, indicating that the device is no longer in a level condition. A similar situation will arise if the device is tipped in the opposite directon, except that D2 will light and D1 will go off.

The circuit may be operated from a small battery which, along with the circuit, may conveniently be mounted within the housing. The device may be switched on and off by a magnetic reed switch SW1 which is not susceptible to contamination by dirt and moisture The LEDs may be mounted in any suitable positions on the housing, say with D1 and D2 at opposite ends of the housing so that they light up to indicate which end of the device is high. Arrowhead shaped LEDs may b used pointing upwards or downwards as r quired to show in which direction the resp ctiv nd must be tipped to achiev a level condition. In devices with long housings the outputs of IC1a and IC1b may each b connect d to tw arrowhead LEDs m unted at opposite ends of the housing with one pointing up and the other down. Thus, when one end of the housing is high a red LED will light at that end

pointing downwards and another will light at the opposite end pointing upwards. Driv transistors may need to be incorporated to drive the additional LEDs. Additional pairs of sensor electrodes could be incorporated into the vial at increasing spacing to drive further LEDs and provide an indication of the degree to which the device is tilted. Amber LEDs could be used to indicate when the device is not approaching a level condition and a two-tone sounder could be used for the same purpose. A bargraph display could also be used. A liquid crystal display could further be utilised in place of LEDs for lower current consumption. A synthesised voice output could be of value to people with impaired vision.

To check for vertical the vial is mounted with its axis perpendicular to the axis of the housing. The same principle could be used for levelling in two mutually perpendicular directions in the horizontal plane, or to check for two mutually perpendicular vertical planes, by using a vial with, say, a circular chamber. A ring of say twelve sensor electrodes could be mounted in the upper wall, i.e. at thirty degree intervals, with the common reference electrode in the centre of the lower wall for example. The outputs from the sensor electrodes could be used to drive twelve LEDs in a circular configuration to indicate when the device was unlevel. A green LED could be sighted in the centre of the ring, triggered from the output of a twelve input CMOS gate to indicate the level condition.

The chamber 2 need not necessarily be barrel shaped. A parallel bore would probably give greater accuracy, although the bubble would probably stabilise faster with a concave surface.

CLAIMS

1. An electronic tilt-sensitive device comprising:

- a sealed chamber containing an electrically conductive liquid and a relatively non-conductive fluid, the chamber having reference electrode means which normally remains in electrical contact with the liquid as the chamber is tilted either side of a datum position, and at least two sensing electrodes arranged such that when the chamber is in the datum position they are in contact with the liquid but when the chamber is tilted either side of the datum position a respective sensing electrode comes into contact with the non-conductive fluid thereby breaking the circuit between that electrode and the reference electrode,

- an lectronic circuit for sensing the presence or absence of an lectrical circuit between the ref r nce lectrode and each of th s nsing electrodes, and

- indicator m ans op rabl by the said lectr nic circuit to indicate (i) when th chamber is in the datum position, (ii) when the chamber is tilted to on side of the datum position, and (iii) when th chamb r is tilted to th opposite side of the datum position.

2. A device according to Claim 1, in which the sensing electrodes terminate substantially flush with the internal surface of the chamber.

3. A device according to Claim 1 or 2, in which the non-conductive fluid is in the form of a bubble which moves in contact with an internal surface of the chamber.

4. A device according to Claim 3, in which, when the chamber is in the datum position, the sensing electrodes are arranged on opposite sides of and in close proximity to the bubble.

5. A device according to any preceding claim, in which the non-conductive fluid is a gas.

6. A device according to any preceding claim, in which the conductive liquid is of relatively low density compared with water.

7. A device according to any preceding claim, in which the conductive liquid is of relatively low surface tension compared with water.

8. A device according to any preceding claim, in which the indicator means provides an audible indication of when the chamber is in the datum position.

9. A device according to any preceding claim, in which the indicator means provides a visual indication of when the chamber is in the datum position.

10. A device according to Claim 9, in which the said visual indication is provided by an LED.

11. A device according to Claim 10, in which the said visual indication is provided by a green LED.

12. A device according to any preceding claim, in which the chamber, the electronic circuit and the indicator means are mounted in an elongate housing.

13. A device according to Claim 12, in which the indicator means comprises visual indicators associated with opposite faces of the housing for indicating the direction in which the housing needs to be moved to restore the chamber to the datum position.

14. A device according to Claim 13, in which the visual indicators comprise pointers which point in the required direction of movement.

15. A device according to Claim 14, in which there are two pointers associated with each of the opposite faces of the housing pointing in opposite directions.

16. A device acc rding to Claim 14 or 15, in which the pointers comprise arrowhead LEDs.

17. A device acc rding to any preceding claim, in which the input part of th electronic circuit which is connect d to th s nsor el ctrodes compris s CMOS devices.

18. A device according to any preceding claim, in which the electronic circuit is

switched on and off by a magnetic reed switch.

19. A vial for use in a tilt-sensitive device according to any preceding claim, comprising a sealed chamber containing an electrically conductive liquid and a relatively non-conductive fluid, the chamber having reference electrode means which normally remains in electrical contact with the liquid as the chamber is tilted either side of a datum position, and at least two sensing electrodes arranged such that when the chamber is in the datum position they are in contact with the liquid but when the chamber is tilted either side of the datum position a respective sensing electrode comes into contact with the non-conductive fluid thereby breaking the circuit between that electrode and the reference electrode.

20. A vial according to Claim 19 having the features specified in any of Claims 2 to 6.

21. An electronic tilt-sensitive device substantially as described with reference to the drawings.

22. A vial substantially as described with reference to the drawings for use in an electronic tilt-sensitive device.

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